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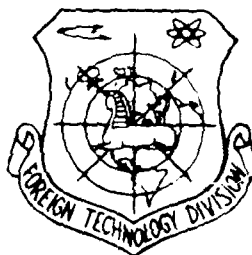
## FOREIGN TECHNOLOGY DIVISION



ANTI-CORROSION ADDITIVES AND OPERATING-PRESERVATIVE  
OILS BASED ON THEM

by

S. E. Kreyn, Yu. N. Shekhter, et al.



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## EDITED TRANSLATION

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By: S. E. Kreyn, Yu. N. Shekhter, et al.

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## ABSTRACT

Expts. with different additives indicated that lubricating oil additives based on nitrated mineral oils possessed effective operational, storage, and anticorrosive properties. Such lubricants sharply reduced the penetrability of water and vapors through the oil film and also the surface tension at the boundaries of oil-water and water-adsorbed oil film. These lubricants increased the contact angle of the oil drop on the water surface and decreased that of the water drop on the oil surface. The O-contg. reaction products, though less effective than the nitro compds. as corrosion inhibitors, together with twice their amt. of the nitro compds., formed mixts. having superior protective properties. Eastern petroleums were first selectively treated to remove polycyclic aromatic hydrocarbons with short side chains and resinous bodies, the presence of which otherwise led to secondary polymn. and condensation reactions, resulting in the formation of asphalt-like substances. The oils were then treated with 30% of HNO<sub>3</sub> (60% concn.), and 10% of stearic acid or synthetic fatty acids added, the latter serving to promote the detergent-dispersive properties of the oils. The acidic nitrated oil was neutralized with CaO, Na<sub>2</sub>O, or their

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mixts., heated to 120° to remove H<sub>2</sub>O, and centrifuged. The resultant additive (AKOR-1) contained 0.9-4.5% ash and its viscosity (at 100°) was 14.1-58.5 centistokes. Strips of steel, cast iron, bronze, brass, Cu, Pb, and other nonferrous metals coated with a thin layer of oil with and without AKOR-1 were exposed to corrosion-forming conditions (heat and moisture). In all cases, corrosion signs appeared much later when AKOR-1 was used in the oil coating. Only 20% of the surface of the steel strips was pitted after a 60-day exposure to heat and moisture when the surface was coated with an oil contg. 10% AKOR-1. Under identical conditions, but without the additive, the entire strip surface was pitted after a 30-day exposure. Automobile parts and gear box details covered with various oils contg. 10% AKOR-1 and stored in the open did not show any signs of corrosion after 19-22 months. The addn. of 10% of AKOR-1 improved the detergent potential of the oil from 20 to 30-50%. The additive did not show any adverse effects on the operational features of motor and transmission oils. In exptl. and actual automobile runs, the components were cleaner, with no changes in the extent of their wear, when the motor oils contained the additive.

## ANTI-CORROSION ADDITIVES AND OPERATING-PRESERVATIVE OILS BASED ON THEM

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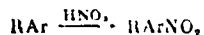
From experience in the operation of auto-tractor equipment it follows that transmission and engine parts, both in the operating process and in storage, are subject to rust under the influence of moisture and acid products which enter the lubricating oil from without, and are also formed within it. Since the market assortment of motor and transmission oils possess unsatisfactory protective (antirust) properties [1], and liquid preservative oils of the type K-17, NG-203 and others are deficient in operating properties [1, 2], the necessity arises to develop operating-preservative oils which simultaneously possess high-level protective and operating properties. Therefore it is necessary to supplement existing commodity oils with additives which improve their operating properties, and also special additives which inhibit corrosion. The employment of operating-preservative lubricating oils increases the period of service of auto-tractor equipment and in the final analysis has a noticeable economic effect.

The employment of the following oil-soluble corrosion inhibitors are recommended as protective additives: the reaction products of thiophosphoric acids with quinoidine compounds in other phosphorus-containing substances [3]; various amino derivatives [4], organic acids, their ethers and salts [5], sulfoacid derivatives [6], nitrated products [7] and others.

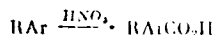
As a result of laboratory investigations of the protective and operating properties of oils with various corrosion inhibitors, it was established that effective protective additives may be obtained on the basis of nitrated oils, which have been subjected to special processing. In the development of the production technology of these additives it was first required to solve certain problems in advance, such as the choice of the raw material for nitrating, and the choice of the nitrating agent; also included was research of optimum nitrating conditions and final product processing. In nitrating

mineral oils, two basic reactions occur:

nitration itself



oxidation



where RAr are alkyl-aromatic and naphtheno-aromatic oil hydrocarbons.

As a result of the oxidation reaction, several oxygen-containing compounds are obtained: acids, hydroxyacids, lactones, ethers and so on, capable of the following secondary reactions:

- a) condensation (polymerization) down to the formation of asphalt-resembling sludges;
- b) nitration, since oxygen-containing oil compounds are nitrated more easily than source oils (the latter is confirmed by the advance nitration of oxidized oils).

The separation of brownish nitrogen oxides ( $\text{NO}_2$ ,  $\text{N}_2\text{O}_4$ ,  $\text{NO}$ ) during the oxidation reaction makes possible in turn the oxidation of hydrocarbons. Therefore, with sufficient separation of nitrogen oxide vapors the oil oxidation process may become autocatalytic.

It is known that in mineral oils polycyclic aromatic hydrocarbons with short side chains and resinous substances are first oxidized and subjected to secondary condensation reactions with the formation of asphalt-resembling products. Therefore oils were chosen for nitrating from which the indicated compounds had been removed in advance through selective refining. The best results were shown by oils AS-9.5, DS-8 and DS-11, obtained from eastern petroleum (Table 1).

In nitrating mineral oils by various means, the direction and depth of the process may be controlled.

The following variations in oil nitrating have been examined.

1. Nitration with nitric acid of various concentrations (from 10 to 98%),

and with various ratios to the oil. In this connection optimum nitrating conditions were chosen in each case: time of introduction and acid sediment, nitrating temperature and others. With an increase in the nitric acid concentration, the content of nitro-compounds increases within the nitrated oil without noticeably increasing oxidation products content. Nitration by weak acids leads to an increase in the oxidation reaction.

2. Nitration by nitrating mixtures, and also by sodium nitrate or sodium nitrite in the presence of sulphuric acid. These methods permit oil nitration with the formation of mononitro-compounds, which lead to minimum oil oxidation reactions.

3. Nitration with catalysts. Through the employment of catalysts of one type or another, it is possible to direct the process either in the direction of nitration (sodium nitrite, acetic acid, zinc stearate), or in the direction of oxidation (mercury salts).

TABLE 1. PHYSICAL-CHEMICAL PROPERTIES OF NITRATED OILS  
(Nitration by 60% nitric acid at 15-55°C for 4 hours)

Indicators	Nitrated Oils					
	spindle 3	AS-6.5	AS-9.5	DS-8	DS-11	MS-20
Quantity of tar formed during nitration, % in oil.....	1.0	1.5	(not available)			0.4
Ash content, %.....	1.3	0.8	1.0	1.2	1.2	0.6
Alkalinity by indicators, mg KOH/g: phenolphthalein.....	3.6	3.6	9.5	3.8	4.3	neutral
bromophenol blue.....	9.5	4.2	30.8	10.1	7.1	
Viscosity at 100°C, centistoke..	9.0	8.7	17.6	17.1	21.0	23.7
Nitrogen content, %	—	—	0.76	0.83	0.89	0.67

The sum of the products of nitration and oxidation, which have been obtained from the nitrated oils through the method of extraction, are then separated with gasoline by means of a second extraction.

It has been proved that nitro-compounds are basic compounds which furnish the high-level protective, dispersive and other properties of nitrated oils. The quantity of nitrogen in them is determined in accordance with the specially developed method (the modified Kjeldahl method) [8], reveals that during nitration under ordinary conditions mononitro-compounds are obtained (the nitrogen content is 3.7 - 3.9%). The nitro group is distributed within the

aromatic (or less frequently within the naphthenic) nucleus, mainly in the para-position to the alkyl radical.

Although oxygen-containing products yield in effectiveness to nitro-compounds, in a certain ratio with the nitro-compounds, equal approximately to 0.5 : 1, they form synergistic mixtures, which possess the highest protective properties. During nitration, therefore, it is not always advantageous to obtain only nitro-compounds, for example, during nitration by anhydrous nitrating mixtures.

AS-9.5 oil, nitrated with 40% [by base oil volume - Tr.] nitric acid of 60% concentration, was chosen as the base for oil and fuel anti-corrosion additives. This oil contains 6-7% nitro-compounds and 4-5% oxidation products.

After the nitration process and the elimination of depleted nitric acid, the acid nitrated oil (acid number 20 mg KOH/g) must be alkalized with some type of neutralizing agent. Sodium salts, calcium salts, magnesium salts and especially lead and zinc salts [9] have revealed good protective and detergent-dispersive properties.

The alkalized nitrated oils possess a high ash content and excess alkalinity, which indicates not only the presence of salts of the type  $(R\text{ArCOO})_2\text{Ca}$  in the oil, but also the presence of a thinly dispersed colloidal suspension  $\text{CaO} - \text{Ca}(\text{OH})_2$ , and possibly also  $\text{CaCO}_3$ , stabilized by surface-active compounds.

A study was made of the actions of nitrated oils and products based upon them (NG-204 and NG-204u liquid lubricants, and AKOR-1 corrosion inhibiting additive). As a result of the investigations conducted it was established that nitrated oils and products based upon them reduce sharply the moisture and vapor permeability of the oil films [9], and also reduce (to zero in a certain concentration) the surface tension at the oil-water and water-oil film adsorption interfaces.

They increase the contact angle of an oil drop on the surface of the water and decrease the contact angle of a water drop on the oil surface. This characteristic is most sharply defined for the AKOR-1 additive, and also for lead and aluminum salts of nitrated oil, i.e., for the most effective corrosion inhibitors. The ability to displace water from a metal surface and not to transmit it through the formed hydrophobic adsorbent films has great practical



significance, since it permits the employment of nitrated oils in preserving damp surfaces, and also in lacquers, primers, paints, waterv fuels and so on.

Investigations conducted in a specialized chamber with external plate polarization by an electric current [1] reveal that sodium and calcium salts of the nitrated oils show clearly the nature of oil-soluble anodic atmospheric corrosion inhibitors, whereas lead and aluminum salts are adsorbent both on the anode and on the cathode portions of corroded metal, and the protection of these portions has a shielding nature.

Two problems are posed in the development of corrosion inhibiting additives for motor and transmission oils.

1. The development of a corrosion inhibiting additive, which upon introduction into base oils or into oils containing a combination of additives, will impart to these oils enhanced protective properties without a deterioration in motor properties.

2. The creation of a multifunctional corrosion inhibiting additive, which upon introduction into base oils will impart to them enhanced protective properties with a simultaneous improvement in detergent and anti-corrosion properties.

Nitrated oils themselves and their salts (sodium, calcium or aluminum salts) may be employed as additives of the first type. Nitrated oil is also chosen as a base for the creation of multifunctional additives of the second type. However, in order to improve the detergent-dispersive properties of additives, the alkalization of acid nitrated oils is carried out with special admixture promoters.

The presence of promoters during alkalization, just as in the application of special technological processes (the simple rapid vaporization of water, the passage of carbon dioxide gas and others), leads to a sharp increase in ash content and alkalinity in the oil-additive mixture, and as a result, to an improvement in the additive detergent properties.

Alkylphenols, arylamines, alcohols, synthetic fatty acids, oxvethylated products and many other compounds were checked by the authors and are recommended as promoters.

Thus after corresponding refinements the following method of obtaining

the AKOR-1 additive was accepted: DS-8 or DS-11 oils of selected purity were processed with 30% nitric acid of 60% concentration, and then a 10% stearic acid was added; the mixture was neutralized with 20% calcium oxide, heated to 120°C to eliminate the water and was centrifuged.

Two production batches of the additive were obtained in accordance with the technique described at an experimental-industrial installation of the "Neftegaz" factory. The material balance of this process is shown below:

Ingredients, %	Results, %
Production of the nitrated oil	
DS-8 mineral oil.....100	Nitrated oil.....103
Nitric acid, 60%..... 30	Volatile products..... 3
Sodium hydroxide (100%).. 3	Depleted nitric acid (30%)..... 20
	Mechanical contaminants. 4
	Losses..... 3
TOTAL.....133	TOTAL.....133
Production of the AKOR-1 additive	
Nitrated oil.....100	AKOR-1 additive.....102
Stearic acid..... 10	Waste..... 28
Calcium oxide..... 20	
TOTAL.....130	TOTAL.....130

Several laboratory batches of the AKOR-1 additive were obtained with the replacement of stearic acid with synthetic fatty acids. It was established that the synthetic fatty acids combine well with the nitrated oil (Table 2), and that the additives obtained thereby are highly effective (Table 3).

The equipment configuration and the technological production diagram for the AKOR-1 additive at the "Neftegaz" factory is examined below.

Mineral oil (Figure 1) and nitric acid continuously enter reaction vessel 1. Heat released as a result of the nitration reaction is carried off by cold water. The reaction mixture enters reaction vessel 2, where the nitration reaction continues for three hours at 55°C. Then the mixture is directed to settling tanks 3 and 4. The depleted acid is drained off by a gravity flow into apparatus 5 and is returned to nitration. The acid nitrated oil enters apparatus 6 where it is mixed with molten stearic acid (or S2hK [synthetic fatty acids - Tr.]) and is neutralized by calcium hydroxide. After this the product is dehydrated in the system consisting of heat exchanger 9 and column 10. From the base of column 10 the product enters centrifuge 12,

where it is heated in reservoir 14 and again cleaned in super-centrifuge 15; from here the prepared additive is directed to market storage.

TABLE 2. PHYSICAL-CHEMICAL PROPERTIES OF THE AKOR-1 ADDITIVE, PRODUCED WITH THE AID OF SYNTHETIC FATTY ACIDS

Indicators	Synthetic fatty acids employed			
	wide fraction, Mendeleyev factory	C <sub>10</sub> -C <sub>16</sub> fraction, Shebskinskiy combine	C <sub>17</sub> -C <sub>20</sub> fraction, Volgograd factory	C <sub>20</sub> -C <sub>30</sub> fraction
Ash content, %				
General	5.6	5.0	5.5	4.9
Sulphate	12.5	10.0	10.2	7.5
Alkalinity by indicators, mg KOH/g:				
Phenolphthalein	41.3	16.7	27.9	10.4
Bromophenol blue	89.4	46.2	76.4	51.9
Viscosity at 100°C, centistoke	44.8	54.8	38.8	41.1

The protective additive AKOR-1 obtained by the process described has a comparatively high ash content (5 - 10%). A decrease in the ash content of the additive was obtained by reducing the calcium hydroxide concentration from 20 to 5%. In neutralizing the acid nitrated oil, a similar effect was obtained through the employment of a mixture of calcium hydroxide and sodium hydroxide in various ratios, or through the use of sodium hydroxide alone. As shown in Table 3, the additive AKOR-1, obtained on the bases of SZhK and sodium hydroxide, preserves its effective protective properties, possesses a reduced ash content and a reduced viscosity level at 100°C.

Laboratory investigations have also established that the viscosity of the AKOR-1 additive may be noticeably reduced and the purity increased if production processing in the final stage is carried out in a gasoline solution. Here the technique is somewhat more complex, since an explosion-proof apparatus and a supplementary device for the elimination of gasoline are required. However, expenses for the construction of such devices are fully justified by the attainment of a high-quality product, according to a number of indicators of the superior quality of additives of a similar type produced abroad.

The protective properties of motor and transmission oils containing the AKOR-1 additive in various concentrations were studied under laboratory

conditions. For this investigation metal plates of steel, cast iron, bronze, brass, copper, lead and other non-ferrous metals were covered with a thin layer of oil with additive and were placed in water, in a humidity chamber, and also in the corrosive atmospheric chamber. In all cases corrosion on the plates appeared later by far than that which occurred during protection of the plates by oils without additives [1, 10]. Generalized curves are shown in Figure 2 as an example of the accumulation of corrosion damage to steel plates in a heat and moisture chamber. When they are protected with market oils, the curve showing damage to the plates with time climbs sharply, and the plates, which are coated with oils having the best protective properties, are fully corroded in not less than 30 days. The difference in the protective properties of oils before and after the addition of functional additives is illustrated by the broad dashed area in Figure 2. Area accumulation in the sources of corrosion after addition to the oil of 10% of the AKOR-1 additive is significantly reduced, and after two months in the chamber not more than 20% of the surface of the plates was corroded.

Data which characterizes the protective properties of oils with the AKOR-1 additive with respect to non-ferrous metals are shown in Table 4.

The good protective properties of oils with the AKOR-1 additive were confirmed during storage of motor vehicle engines and transmission in an open area (Table 5).

Several physical-chemical and operating characteristics of the oils undergo changes after the oils are supplemented with the AKOR-1 additive (Table 6).

Thus the viscosity level of the oil increases at 100°C, and the ash content increases. The anticorrosion and detergent properties of the oil are significantly improved. No significant negative effects of the protective additive on the motor and transmission oil quality indicators were established.

The operating properties of motor oils with the AKOR-1 additive were checked during bench tests on the OD-9 (one-cylinder power-boosted diesel), GAZ-69, YaAZ-238, 2Ch-8.5/11, URAL-375 and during operational tests on the GAZ-51, ZIL-157 and KRAZ-214 motor vehicles. In all cases it was noted that with the addition of the AKOR-1 additive, engine parts remained cleaner, and wear remained practically unchanged.

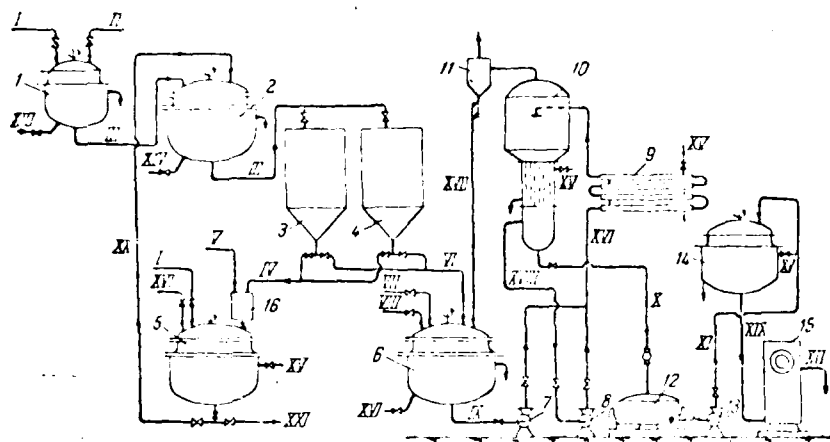
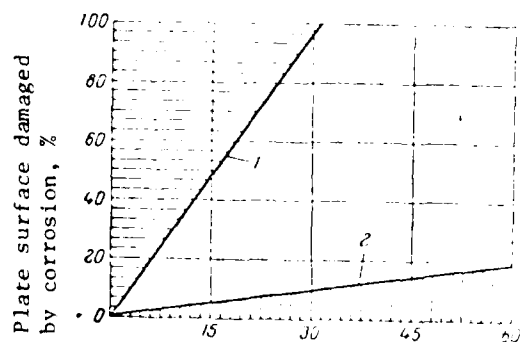


Figure 1. Technological production diagram for AKOR-1 additive.  
 1, 2 - reaction vessels; 3, 4 - settling tanks; 5 - apparatus for replenishing depleted nitric acid; 6 - mixer-neutralizer; 7 - pump for product delivery to heat exchanger; 8 - circulating pump; 9 - heat exchanger; 10 - water stripping column; 11 - spray separator; 12 - centrifuge; 13 - pump for product delivery for final centrifuging; 14 - relay pumping reservoir; 15 - supercentrifuge; 16 - nitric acid batcher.  
 Lines: I - mineral oil; II - 60% nitric acid; III - acid-oil emulsion; IV - depleted acid; V - 98% nitric acid; VI - nitrated oil in the mixer-neutralizer; VII - molten stearic acid or SZhK; VIII - milk of lime; IX - water product; X - dehydrated product for centrifuging; XI, XIX - product for final centrifuging; XII - AKOR-1 additive; XIII - cold water; XIV - hot water; XV - vapor; XVI, XVIII - dehydrated circulating product; XVII - target product; XX - 60 % nitric acid, separated from depleted acid; XXI - nitric acid drain.



Duration of exposure in heat and moisture chamber, days

Figure 2. Curves of corrosion damage accumulation to the surface of steel plates with time (heat and moisture chamber G-4, seven hours at 50°C, 17 hours at 20°C; humidity 100%; plate material St. 3): 1 - market oils; 2 - market oils + 10% AKOR-1.

TABLE 3. THE PRODUCTION OF AKOR-1 ADDITIVE BY FORMULATION

TABLE 2. THE PRODUCTION OF AKOR-1 ADDITIVE BY FORMULATION											
Oil, sub- jected to nitration by a 60%	Admixture (10% of the nitra- ted oil)	Neutraliz- ing agent	Neutra- lizing agent quantity, process- ing, % of nitrated oil	Quantity of resi- due after process- ing, % of nitrated oil	Sample properties of the AKOR-1 additive produced with different formulations						
					Alkalinity by indicators, mg KOH/g	Vis- cos- ity	Solubility in oils	10% in MT-16	10% in trans- former oil		
AS-9.5	stearic acid	calcium hydroxide	5	-	3.8	2.3	46.7	26.1	14 days (no resi- due)	14 days (no re- sidue)	14 days (no re- sidue)
AS-9.5	"	sodium hydroxide	2.5	25.2	0.9	2.9	6.9	19.9	1 day (no resi- due)	26 days (no re- sidue)	26 days (no re- sidue)
AS-9.5	SZhK* C <sub>20</sub> -C <sub>30</sub> fraction	calcium hydroxide	5	5.7	3.4	6.6	55.0	39.3	50 days (no resi- due)	50 days (limited residue)	50 days (limited residue)
AS-9.5	"	sodium hydroxide	1.8	5.3	1.8	2.5	16.3	53.0	40 days (no resi- due)	-	-
AS-9.5	SZhK, C <sub>16</sub> -C <sub>20</sub> fraction	"	2.0	25.0	1.0	5.3	18.4	14.1	1 day (residue)	-	-
AS-9.5	"	"	1.5	5.0	3.0	-1.2	46.9	31.8	40 days (no resi- due)	-	-
AS-9.5	"	calcium hydroxide	2.0								
DS-11	stearic acid	"	5.0	-	4.0	0.9	49.9	26.1	14 days (no resi- due)	14 days (no re- sidue)	14 days (no re- sidue)
DS-11	stearic acid	sodium hydroxide	2.5	23.2	1.0	5.2	5.3	25.0	1 day (residue)	27 days (no re- sidue)	27 days (no re- sidue)

TABLE 3 (continued)

Oil, subjected to nitration by a 60% concentration of the nitration of nitric acid (30% of base)	Neutralizing agent	Neutra- lizing agent quantity, % of ni- trated oil	Quantity of resi- due after process- ing, % of nitrated oil	Sample properties of the AKOR-1 additive produced with different formulations					
				Ash con- tent, %	Alkalinity by indicators, mg KOH/g	Vis- cos- ity at 100°C centi- stokes	Solubility in oils		
					phenol- phtha- lein	centi- blue	10% in MT-16	10% in trans- former oil	
DS-II	stearic acid	sodium hydroxide	2.0	3.75	2.5	52.7	58.5	78 days (no resi- due)	36 days (no re- sidue)
DS-II	"	calcium hydroxide	3.0						
DS-II	SZhK, C <sub>16</sub> -C <sub>20</sub> fraction	sodium hydroxide	3.0	14.2	1.7	4.1	28.0	23 days (limited residue)	23 days (limited residue)
DS-II	"	calcium hydroxide	5.0	-	4.5	1.7	54.3	16 days (no residue)	
DS-II	"	sodium hydroxide	2.0	4.7	3.7	2.5	44.8	78 days (no resi- due)	78 days (limited white residue)
DS-II	"	calcium hydroxide	3.0						

\* synthetic fatty acids - Tr.



TABLE 4. AN EVALUATION OF THE PROTECTIVE PROPERTIES OF OILS IN AN EXHAUST GAS CHAMBER (30 minutes at 50°C; 2 hours at 20°C)

Oil	Condition of non-ferrous metal plates after tests					
	Bronze		Brass		Aluminum	
	condition of the surface	surface corrosion damage %	condition of the surface	surface corrosion damage %	condition of the surface	surface corrosion damage %
DS1-11	brownish deposit	50	brown pitting	50	slight darkening of the entire surface	-
DS1-11+10% AKOR-1	no change	0	barely discernible pitting	20	no change	0
MT-16	brownish deposit	70	dark-brownish pitting	50	dark-colored pitting	50
MT-16+10% AKOR-1	no change	0	barely discernible pitting	20	no change	0
MT-16p	fine dark-colored pitting	100	dark-colored pitting	70	slight darkening of the entire surface	-
MT-16p+10% AKOR-1	no change	0	barely discernible pitting	10	no change	0

TABLE 5. SURFACE CONDITION OF PARTS, UNITS AND ASSEMBLIES PREPARED FOR MOTHBALLING THROUGH THE EMPLOYMENT OF MARKET OILS WITH AKOR-1 ADDITIVE

Type, vehicle service number, list of mothballed surfaces, units and assemblies	Oil	Length of storage and surface condition	Oil film condition; presence of water and deposits
Motor Vehicle Ural-375, No. 5			
Smooth surfaces of engine cylinders, compressor and valves	90% DS-8 + + 10% AKOR-1	21 months (no corrosion)	thin continuous oil film
Transmission			
Gear teeth and shaft spline surfaces	90% MT-16p + + 10% AKOR-1	"	"
Engine YaAZ-206-A			
Smooth surfaces of engine cylinders, the distributor mechanism, and the compressor	90% DS-8 + + 10% AKOR-1	19 months (no corrosion)	"
Transmission YaAZ			
The surfaces of gear teeth, shafts, guide pulleys, and shifting forks and stops	90% MT-16p + + 10% AKOR-1	"	"
Engine GAZ-51			
Smooth surfaces of engine cylinders	90% ASp-9.5 + + 10% AKOR-1	"	"
GAZ-51 Transmission			
The surfaces of gear teeth, shafts, guide pulleys, shifting forks and stops	90% niger oil + + 10% AKOR-1	19 months (no corrosion)	"
Cylinder block, GAZ-69 engine			
Smooth surfaces, contact areas	90% DS-8 + + 10% AKOR-1	20 months (no corrosion)	"
	90% AS-9.5 + + 10% AKOR-1	19 months (no corrosion)	Thin oil film, jet-like oil flows on the smooth surface

TABLE 5 (continued)

Type, vehicle service number, list of mothballed surfaces, units and assemblies	Oil	Length of storage and surface condition	Oil film condition; presence of water and deposits
Smooth surfaces, contact areas	90% MT-16p + 10% AKOR-1	19 months (no corrosion)	Thin oil film, jet-like oil flows on the smooth surface
GAZ-51 Transmission			
The surfaces of gear teeth, shafts, guide pulleys, shifting forks and stops	90% MT-16p + 10% AKOR-1	22 months (no corrosion)	Thin oil film
GAZ-69 Transmission			
The surfaces of gear teeth, shafts, guide pulleys, shifting forks and stops	90% TAp-15 + 10% AKOR-1	19 months (no corrosion)	" " "

TABLE 6. PHYSICAL-CHEMICAL AND OPERATING PROPERTIES OF DSp-11 OIL WITH 10% AKOR-1 ADDITIVE

Indicators	Oil with no additive	Additive					
		nitrate <sup>d</sup> DS-8 + 10% stearic acid : 10% Ca(OH) <sub>2</sub>	nitrate <sup>d</sup> AS-9.5 + 10% stearic acid + 5% Ca(OH) <sub>2</sub>	nitrate <sup>d</sup> AS-9.5 + 10% SZHK (C <sub>20</sub> -C <sub>30</sub> ) + 10% Ca(OH) <sub>2</sub>	nitrate <sup>d</sup> AS-9.5 + 10% SZHK (C <sub>20</sub> -C <sub>30</sub> ) + 10% NaOH	nitrate <sup>d</sup> AS-9.5 + 10% SZHK (C <sub>17</sub> -C <sub>20</sub> ) + 5% Ca(OH) <sub>2</sub> + 5% NaOH	nitrate <sup>d</sup> AS-9.5 + 10% SZHK (C <sub>10</sub> -C <sub>16</sub> ) + 3% Ca(OH) <sub>3</sub> + 2% NaOH
Viscosity, centistoke							
at 100°C. . . . .	10.5	11.5	10.74	11.25	11.55	11.1	11.52
at 50°C. . . . .	60.3	69.0	61.2	66.2	68.2	65.4	-
Ash content, % . . . .	0.26	0.86	0.60	0.58	0.37	0.55	0.53
Temperature, °C							
flash point . . . . .	226	238	-	225	-	223	225
solidification point. . . . .	-22	-23	-22	-22	-21	-21	-24
Heat oxidation stability T <sub>250</sub> , min.	36	33	31	30	29	27	25
Detergent potential .	20	-	50	45	45	38	30
Detergent properties on the PZV* device, points . . . . .	1.5	0-0.5	0-0.5	0-0.5	0.5	0.5	0-0.5
Carbon deposits at 400°C, % . . . . .	1.6	6.3	5.1	6.1	6.9	6.8	6.4
Anticorrosion properties by the PZZ* device at 200°C (lead) . . . . .	164	86	-	-	-	-	-

\* This is apparently an equipment type number. Expansion of the abbreviation is unknown - Tr.

### Conclusions

1. The AKOR-1 protective additive was produced on a base of nitrated oils, which were treated with calcium hydroxide, sodium hydroxide, or a mixture of the two, with stearic acid, SZhK and other compounds.
2. The technological design of the additive production process was developed and perfected.
3. The AKOR-1 additive effectively improves the capability of market motor and transmission oils to protect steel, cast iron and non-ferrous metals from rust and corrosion.
4. Insofar as detergent and anticorrosion properties are concerned, oils with the AKOR-1 additive are superior to oils without the additive, and in other respects do not differ from the oils without additives.
5. The additive AKOR-1 in pure form or diluted with low-viscosity oil may be employed on an equal footing with liquid mothballing oils for the internal protection of machinery.
6. The additive AKOR-1, when added to motor and transmission oils in a 10% concentration, passes the following tests under actual operating conditions with positive results:
  - a) protective properties: this lubricant was employed to mothball motor vehicle engines and transmission assemblies during storage in an open area for more than 20 months;
  - b) operating properties: this lubricant was employed during bench tests of the OD-9, 2Ch-8.5/11, GAZ-69, YaAZ-233 engines and during operational tests for the GAZ-51, ZIL-157 and KRAZ-214 motor vehicles.

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